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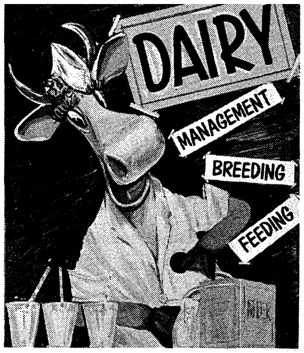
Harvesting, Storing and Feeding Quality Forages

Purdue University Cooperative Extension Service



HARVESTING, STORING AND FEEDING QUALITY FORAGES

Dairy Extension Office 1/

Modern concepts of livestock production revolve around growing and efficiently using farm-produced forage. The place of forages in the farm management scheme, in good land use practices and in land conservation is established beyond doubt. Forages grown on efficiently managed land can be made to yield large amounts of essential feed nutrients comparable to those of other crops and at lower costs. On the other hand, poorly managed forage crops can be low yielding and expensive feeds. Unfortunately, too much of the land in forages is not as productive of feed nutrients as it could be, and there is opportunity here for farmers to increase their livestock feed supply.

Relation of Forage Quality to Feeding Value

High quality in forage may be described by the following physical characteristics: (1) Evidence of early maturity; (2) leafiness (especially legume or legume-grass mixed forage); (3) soft and pliable, free from steminess; (4) green and bright in color; (5) relatively free from undesirable weeds and grasses; (6) free from dust and mold. In the absence of actual chemical and feeding tests to indicate nutritive values, USDA officials have utilized certain of these physical characteristics to classify hays into official U.S. grades to use as a guide in determining the quality of different hays. Classifying silages and pasture forage is more difficult, and satisfactory standards have not yet been established. There is need for further work in establishing simple and descriptive grade standards for all types of forage and to relate grades to feeding values. Some work is being done in this regard with hays.

Harvesting hay in the early stages of maturity also produced greater yields of digestible protein and nutrients per acre. This is illustrated in Tables 1 and 2 reporting results of a 3-year study on the yield and feeding value of alfalfa hay harvested at three stages of maturity. When these hays were fed to milking cows as the only feed, the production of milk per cow per day was greater and the hay required to support a cow and produce 100 pounds FCM was less for the initial bloom hay than for that cut at later stages. The calculated milk yield per acre of the initial-bloom hay was 20 percent greater than for the half-bloom hay and 63 percent greater than for the full-bloom hay. Much of this big difference was caused by the lower total seasonal yield of the hay cut in the later stages of maturity.

These and other available data clearly indicate that one good way for farmers to insure higher quality nutritious feed with larger yields of digestible nutrients per acre is to harvest their forage crops in the early stage of maturity. Extension workers can well afford to emphasize the importance of this practice to farmers.

1/ This Mimeo is a summary of USDA Agricultural Research Service Publications 52-11 and 44-23.

Table 1. Protein content and yields of dry matter, protein and total digestible nutrients per acre of alfalfa harvested at initial, half, and full bloom stages (3 year average) a/

Stage of maturity	Protein content	Dry Matter digestibility b/	Dry matter yield	Protein yield	TDN yield (calculated)	TDN content b/
	Percent	Percent	Pounds	Pounds	Pounds	Percent
Initial bloom	18.2	77.7	7,896	1,427	4,660	59.0
Half bloom	18.3	77.1	7,778	1,381	4,413	56.7
Full bloom	15.7	75.4	6,061	977	3,269	53.9

a/ From USDA Tech. Bul. 739, 1940.

b/ Determined with sheep on the 1937 crop of hay and used for the average for the 3 years.

Table 2. Comparative calculated milk production per acre of alfalfa harvested at three stages of maturity and fed to dairy cows a/

Stage of maturity	Average daily		Hay required for support of cow and 100 pounds FCM	Estimated yield of milk per acre
	FCM produced	TDN required		
			Pounds	
Initial bloom	27.9	19.6	141.6	6,194
Half bloom	23.6	19.2	167.8	5,145
Full bloom	20.8	17.9	176.6	3,814

a/ Adapted from USDA Tech. Bul. 739, 1940.

Table 3. Losses of dry matter and feed nutrients from alfalfa mixed forages harvested and stored in different ways a/

Component	Unit	Field-cured hay		Barn-finished hay		Silage
		Rained on	No rain	No heat	Heat	
Dry matter	%	36.6	21.0	19.0	15.2	16.8
Protein	%	46.1	27.7	24.0	21.3	16.9
Carotene	%	99.1	96.8	93.7	89.6	80.9
TDN	%	42.1	25.5	24.0	20.5	19.5
Net energy	%	47.2	29.6	28.6	25.5	19.5

a/ Adapted from Table 69, USDA Tech. Bul. 1079, 1954.

Relation of Harvesting and Storage to Feeding Value

Forages intended for barn feeding, even though properly grown for high yield and high nutrition and cut at the proper stage of maturity, still must face the hurdles of harvesting and storage before they get to the cows. Harvesting methods and weather conditions prevailing during harvesting have much to do with the appearance, character, quality and nutritive value of the preserved forage. With the changes in these characteristics of forage during harvesting and storage, go variable losses in dry matter and feed nutrients, which are not so apparent to the average person. The best way to harvest and store forage presents a critical problem to every dairyman, especially those in the humid and semi-humid regions.

Only recently have we become fully aware of the high feed losses that occur from harvesting and storing forage. Beltsville research on this problem is summarized in Table 3. The losses resulting from harvesting forage from the same fields by four different methods were carefully measured over a 6-year period. The high losses of feed nutrients observed are rather typical of what is happening when forages are harvested in the humid regions. The losses from field curing were staggering. The silage method appeared the most practical and next most efficient. Barn drying, using heat, closely approximated the silage method, but it is usually difficult to provide a source of heat with most farm installations. The silage method reduces losses by one-third to one-half compared with field curing.

Table 4. Estimated comparative yields of feed nutrients from alfalfa mixed forage when harvested in different ways, and the grain sparing effect of improved harvesting methods a/ b/

Method of harvest	Per acre yield of feed: Protein	Per acre yield of feed: Digestible protein	Per acre yield of feed: Total digestible nutrients	Increase over average of 1 & 2c/: Protein	Increase over average of 1 & 2c/: Digestible protein	Increase over average of 1 & 2c/: Total digestible nutrients	Grain mix equivalent d/
				Pounds			
Field-cured hay - rain	571	393	1,795	-	-	-	-
Field-cured hay - no rain	715	505	2,336	-	-	-	-
Barn dried hay - no heat	753	536	2,347	110	87	281	375
Barn dried hay - heat	784	562	2,463	141	113	397	530
Wilted silage	832	568	2,517	189	119	451	600
Dehydrated hay	803	547	2,703	160	98	637	850

a/ Adapted from Tables 68 and 69, USDA Tech. Bul. 1079, 1954.
b/ Assuming a dry matter yield in each case of 2 1/2 tons per acre.
c/ Assuming that at least half the crop would be rained on during harvest.
d/ A 24 percent grain mixture containing 75 percent TDN.

The comparative yields of available protein and digestible nutrients from a standing crop yielding 2 1/2 tons of dry matter per acre have been estimated in Table 4. The saving in digestible protein and TDN, when using alternatives to field curing, point up the opportunities for farmers to increase the efficiency of their feed production methods and reduce the purchased feed bill. To illustrate, when figured on a grain replacement basis, making silage compared to making field-cured hay saved as much TDN and more protein than is contained in 600 pounds of a 25 percent grain mixture.

As shown in Table 5, the silage and artificial drying methods of harvesting were much more effective in preserving the leaves and the green color of the forage than were the various methods of making hay.

Grass Silage High in Feeding Value

Results like these indicate why we are giving so much attention to grass silage as a way of harvesting the forage crop. Comparative feeding tests on these same experimental forages, as indicated in Table 6, show that when the different forages were fed at about the same level of dry matter intake the silage was at least as palatable and effective in maintaining milk production as the dry forages, and better than the poorer grade field-cured hay that was damaged by rain. The silage made was of moderate moisture content, due to slight wilting of the forage. The forage was ensiled without a preservative and was of good quality.

Present Knowledge of Silage Making

Despite the importance of silage making in our agricultural economy, the research effort going into the problems associated with silage making is indeed small compared to other agricultural problems. Much of the research effort in the past has been exerted through trial and error techniques. The wilting method was developed at Beltsville using this technique but did not produce information concerning the fundamental processes involved.

The techniques of chemistry, bacteriology, agricultural engineering, agronomy, and plant physiology have not been utilized in a team attack on the problems of silage making. Though the processes are somewhat similar, it has been said that we know more about the scientific principles of producing sauerkraut than we know about making grass silage.

Briefly, according to our present knowledge, we know that silage is made primarily by the fermentation of the carbohydrates in the plant material with the resulting production of certain organic acids such as butyric, lactic, formic and acetic acids. The organic acids increase the acidity of the silage which aids in it preservation. We know that exclusion of oxygen from the silage mass is important in the fermentation process. This important principle is sometimes not fully appreciated by farmers. We know that silage can be made in different structures with differing success and varying losses. We know that the proper use of the wilting procedure or the use of different types of preservatives will usually produce a good silage. We have some knowledge of the feeding value of the grass silages.

Despite the development of modern machinery, new types of structures for storage and new preservatives, the scientist does not have the answers for those seeking information concerning the effects of these new developments on the silage making process, because of the primary lack of fundamental information.

The Water Problem

Prior to the development of the direct-cut field forage chopper, a great deal of the

Table 5. Effect of method of harvesting on leaf content and color of alfalfa forage a/

Method of harvest	Leafiness: As cut	Leafiness: After harvesting	Color: As cut	Color: After harvesting
		Percent		
Field-cured hay - no rain	50	40	69	50
Field-cured hay - rained on	49	29	74	29
Barn-dried hay - heat	46	40	69	56
Barn-dried hay - no heat	47	42	66	51
Wilted silage	48	48	69	56
Dehydrated hay	47	48	71	52

a/ Adapted from Table 72, USDA Tech. Bul. 1079, 1954.

Table 6. Results of comparative feeding tests using forage harvested in different ways a/

Items compared	Unit	Field-cured hay: Rained on	Field-cured hay: No rain	Barn-dried hay: No heat	Barn-dried hay: Heat	Wilted Silage	Dehy-drated hay
Number trials		1	2	3	3	5	2
Milk production (FCM), avg. daily	lb	35.2	35.0	33.7	35.7	34.4	35.7
Avg. 30-day decline in production	%	13.6	6.7	8.1	8.8	7.3	6.4
Change in weight, avg. daily	lb	-.19	+.20	-.12	-.12	+.10	+.01
Dry matter consumed from experimental forage, avg. daily	lb	14.3	17.7	19.0	18.2	17.9	17.0
Total dry matter consumed, avg. daily	lb	30.2	31.4	32.7	33.1	32.1	31.6
Dry matter consumed per 100 pounds weight, experimental forage avg. daily	lb	1.24	1.58	1.65	1.53	1.52	1.46
Total dry matter consumed per 100 pounds body weight, avg. daily	lb	2.62	2.80	2.85	2.79	2.73	2.71

a/ Adapted from Table 74, USDA Tech. Bul. 1079, 1954

Table 7. The water problem in high moisture silage in a tower silo

100 tons wilted crop	175 tons fresh green crop
65% moisture	80% moisture
65 tons water	140 tons water
35 tons DM as silage	35 tons DM as silage

Difference 75 tons water

12% fermentation loss	15% fermentation loss
3% field loss	13% seepage loss
15% total loss	28% total loss

Difference 13% of DM or 4.5 tons DM
or 5.3 tons of hay equiv.

To bring 80% moisture crop to 60% moisture would require 20 tons of beet pulp or about 230 lbs. beet pulp per ton equal to 36% of the DM in the silo.

Table 8. Estimated seepage dry matter losses from tower silos

Moisture percent	Dry matter loss percent
75	8-15
70	5-8
65	1-2
	1

grass silage was made by means of the wilting procedure.

The wilting procedure consists of cutting the crop with a mower, permitting the crop to wilt from 1 to 5 hours until the moisture content is between 60 and 70 percent, raking with a side delivery rake, chopping from the windrow into wagons or picking the crop up with a hayloader onto trucks, chopping and blowing into the silo. On the other hand, the direct-cut forage chopper cuts, chops and blows the crop directly into trucks or forage wagons and thus does not permit wilting the crop in the field. This introduces a new set of problems. The water problem as a result of the use of the direct-cut chopper is illustrated in Table 7.

Table 7 shows that the farmer must handle 75 more tons of water if his crop contains 80 percent moisture compared to the wilted crop containing 65 percent moisture in order to store a total of 35 tons of dry matter. This dry matter fraction excludes moisture and contains all of the nutrients obtained from the crop.

Besides the extra power required to handle the 75 tons of water, a seepage problem is also created. When the crop contains 80 percent moisture, one might expect as much as 50 tons of water to seep from the tower silo carrying with it valuable nutrients. Seepage contains 7 to 8 percent dry matter. In experiments at Beltsville, the total DM loss from the stored dry matter from a high moisture crop will be between 8 and 15 percent in the form of seepage. The effect of the moisture content of the crop on seepage dry matter losses is shown in Table 8.

Considering the information in Table 7, comparing the losses in making wilted silage and wet silage, there can be as much as 13 percent difference in loss of DM from these two theoretical silages or a difference of 4.5 tons of DM from the original 35 tons of DM.

The seepage loss according to preliminary data at Beltsville will be about halved if the silage is stored in a horizontal silo such as the bunker silo. Further data are needed on this point. Likewise, we need further data on the effect of type of crop, depth of storage and length of cut on seepage losses.

The addition of a feedstuff which has the ability to take up water has been helpful. However, as shown in Table 7, about 230 pounds of beet pulp would be required per ton of wet silage to lower the moisture equivalent from 80 to 70 percent. Such addition of best pulp would result in the silage dry matter containing 36 percent beet pulp as it is stored. This raises the question of whether the farmer has the silo for the purpose of storing beet pulp or forage.

In laboratory studies at Beltsville, the water holding capacity of several feedstuffs was studied as shown in Table 9. Citrus pulp, beet pulp and ground hay were best, dried distillers grains intermediate, while ground cereal grains were poorest. The use of chemical preservatives does not reduce the seepage problem.

Table 9. Water uptake of 30 grams of feedstuffs following 5.0 pounds pressure per square inch

Feedstuff	Water (grams)
Beet pulp	97
Beet pulp (ground)	91
Citrus pulp	63
Citrus pulp (ground)	63
Brewers' grain	46
Corn cobs	44
Corn cobs (ground)	64
Bran	10
Corn meal	9
Chopped hay	63
Ground hay	50

Plastic Covers on Bunker Silos

The development of plastic sheets or covers will be largely responsible for the continued use of horizontal storage. The plastic cover prevents rain or snow from penetrating the silage mass, and excludes air from the large surface of horizontal silos. The usually large loss of 30 to 40 percent or more of the dry matter attendant with poor packing or heavy rainfall in the uncovered horizontal silo can be reduced to 15 percent. This loss is primarily due to fermentation and seepage with little or no surface spoilage.

The cover must be weighted with a material, like sawdust, over the entire surface. Weighting at the edges is not sufficient because air entering in one or two holes will expose the entire surface of the silage. The weighting material tends to confine the loss from a hole or puncture to a small area. The spoilage per square foot is a minimal figure for this loss since gaseous losses such as carbon dioxide are not accounted for in the spoilage. Data show that in 1954, spoilage loss amounted to 6 to 7 pounds of dry matter per square foot whereas by proper application of the cover loss was reduced to 0.2 to 0.5 pounds per square foot. If forage dry matter were assigned a value of 1 1/2 cents per pound (equivalent to 15 percent moisture hay at $25.50 per ton) the plastic cover would be worth 10 1/2 cents per square foot, plus the unknown value of gaseous loss, reduced leaching by rain, and decreased labor for removal of spoilage. Thin plastic covers applied from 6 to 20 foot wide rolls can be obtained for 2 to 3 cents per square foot and replaced each year. It is believed that the same information would apply to trench silos.

The farmer who believes that he has very little loss where no cover is used or where the silage is covered with lime or similar materials is only fooling himself,

Table 10. Estimate of minimum dry matter losses in forage stored silage at different moisture levels a/

Kind of silo, and moisture content of forage as stored	Dry matter losses: Surface spoil-age b/	Fermen-tation c/	Seepage	Total silo losses	Field losses	From cutting of crop to feeding
	Percent					
Conventional tower silos:						
85 percent	3	10	10	23	2	25
80 percent	3	9	7	19	2	21
75 percent	3	8	3	14	2	16
70 percent	4	7	1	12	2	14
65 percent	4	8	0	12	4	16
60 percent	4	9	0	13	6	19
Gas-tight tower silos:						
85 percent	0	10	10	20	2	22
80 percent	0	9	7	16	2	18
75 percent	0	8	3	11	2	13
70 percent	0	7	1	8	2	10
65 percent	0	6	0	6	4	10
60 percent	0	5	0	5	6	11
50 percent	0	4	0	4	10	14
40 percent	0	4	0	4	13	17
Trench silos:						
85 percent	6	11	10	27	2	29
80 percent	6	10	7	23	2	25
75 percent	8	9	3	18	2	20
70 percent	10	10	1	21	2	23
Stack silos:						
85 percent	12	12	10	34	2	36
80 percent	12	11	7	30	2	32
75 percent	16	11	3	30	2	32
70 percent	20	12	1	33	2	35

a/ Conservative estimates for careful filling methods and good drainage, based on 6 months storage. Plastic caps or other good covers will reduce top spoilage. Poor compacting and sealing of the silage and excessive rainfall or melting snow on uncovered trenches and stacks will increase losses. From Bureau of Dairy Industry - Inf. 149, "Developments and Problems in Making Grass Silage," 1953.

b/ Includes side and end spoilage in trenches and stacks.

c/ Allowance made for some heating and flake mold at the lower moisture levels.

Table 11. Relation between the moisture content of silage and the amount of silage dry matter consumed by dairy cows a/

Crop harvested	Moisture content of silage	Dry matter eaten per 100 pounds of live weight per day
	Percent	Pounds
Orchard grass		
First cutting (boot stage):		
Fresh green	79.7	1.36
Wilted	66.9	2.00
Second cutting (early hay stage):		
Fresh green	71.8	2.08
Fresh green + 5% dry grain	69.7	2.21
Wilted	59.5	2.11
Alfalfa:		
First cutting (1/10 to 1/4 bloom):		
Fresh green	77.9	1.23
Wilted (73%)	72.7	1.94
Wilted (65%)	65.6	2.34
Half-dry b/	45.7	2.52
Soybeans:		
First pods forming (dry season):		
Fresh green	74.1	1.52
Fresh green + 10% dry grain	69.9	2.19
Wilted	58.1	1.85

a/ From Beltsville experiments in 1950-52, reported in BDI-Inf. 149, 1953.
b/ In gas-tight silo; no mold.

especially in areas where there is considerable rainfall. He does not realize the extent of loss due to carbon dioxide escaping into the air from fermentation, or the amount of silage dry matter loss represented by 2 or 3 inches of black top spoilage.

If trench and bunker silos continue to be used, and there is reason to believe that they will, properly weighted plastic covers will increase in use. In areas where there is considerable rainfall they are essential.

Factors Affecting Palatability of Grass Silage

If we are to place more emphasis on forage in the ration and at the same time place more dependence on grass silage instead of hay, the silage must be of good quality and palatable so that cows will eat it in large amounts. Our knowledge of what constitutes a highly palatable silage--one that cows like and will eat a lot of--is limited. The strong odors of some silages do not seem to affect the cows as much as they do people. Our experience tells us that cows and heifers will consume more dry matter from silage with a relatively low moisture content than from silage of high moisture content, ensiled with or without a preservative. Table 11 summarizes some of our information on this point. This is a compelling reason, among several others, for putting up silage with a moderate moisture content, 63 to 70 percent.

Getting More Milk from Forage

When a farmer has developed an adequate supply of high-quality, palatable forage that is available to his herd with a minimum loss of feed nutrients, he has the basis for an adequate economical dairy ration. He should then, under most conditions, adjust the size of his herd to fit the forage supply; providing each cow with all she will eat. Grain should be added to the ration to get extra milk insofar as it is economical and does not materially reduce forage consumption.

This does not appear to be the way farmers have been feeding their herds during the past 2 decades. Department reports indicate that since 1953 the amount of grain fed per cow per year has increased from 943 pounds to 1,739 pounds in 1954. The pounds of grain fed per 100 pounds of milk produced have increased from 22.5 pounds to 30.0 pounds. This means that a proportionately smaller amount of the nutrients required for milk production is coming from forage. The practice of feeding more and more grain, while an easy way to increase milk production, adds to the cost of milk production because nutrients are more expensive in grain than in home-produced forage. This trend can be checked by producing more and better forage.

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